METHOD AND APPARATUS FOR MANAGING DISC DEFECTS

Technical Field

The present invention relates to disc defect management, and more particularly, to a method and apparatus for managing a defect in a disc, in a manner regarding different types of data.

Background Art

Defect management is a process of rewriting the data stored in a user data area of a disc in which a defect exists. The data is rewritten to the disc's data area, thereby compensating the data loss caused by the defect. In general, defect management is performed using linear replacement or slipping replacement. In linear replacement, the user data area in which a defect exists is replaced with a spare data area having no defects. In slipping replacement, the user data area with the defect is slipped and the next user data area having no defects is used.

Both linear replacement and slipping replacement are applicable only to discs, such as a DVD-RAM/RW, on which data can be repeatedly recorded and recording can be performed using a random access method. In other words, linear replacement and slipping replacement are difficult to apply to write once discs on which recording is allowed only once.

In general, the presence of defects in a disc is detected by recording data on the disc and confirming whether or not data has been recorded correctly on the disc. However, once data is recorded on a write once disc, it is impossible to overwrite new data and manage defects therein.

After the development of CD-R and DVD-R, a high-density write once disc with a recording capacity of several dozen GBs was introduced. This type of disc can be used as a backup disc, since it is not expensive and allows random access which enables fast reading operations. However, defect management is not available for write once discs. Therefore, a backup operation is discontinued when a defective area, i.e., an are

a where a defect exists, is detected during the backup operation because defect management on a write once disc is not performed. In general, a backup operation is performed when a system is not frequently used, e .g., at night when a system manager does not operate the system.

Recording of user data recorded from a defective area of the data area to the data area for defect management, is not always preferable. For real-time reproduction of data, it is important to appropriately read da ta on time. In general, audio/video (AV) data requires reproduction in re al time, for it is perceived by the visual and auditory senses of a human b eing during reproduction. Human visual and auditory senses are more s ensitive to an error in real-time reproduction of AV data than an error in r eproduction of specific AV data content caused by a trivial defect contain ed in the AV data. In fact, human ears are incapable of detecting an err or when audio data is incompletely reproduced. As specified previously, when an area of a disc is designated as a defective area, slipping repla cement can be used to rewrite data to a following area. That is, when a n area of a disc is designated as a defective area, the following area whe re data is recorded is also considered as unavailable and determined to be a defective area, and the data recorded in the defective area is rewritt en. In this case, the defective area is skipped and data is read from the next area during reproduction of the data. However, skipping the defe ctive area causes a delay in reading data from the disc, and the delay in reading makes it difficult to reproduce data in real-time. As described a bove, human ears are more sensitive to an error caused by a failure of re al-time reproduction than an error caused by incomplete reproduction of AV data. Unlike AV data, it is very difficult to reproduce, edit, or search for control data when even a small amount of the control data is lost.

Disclosure of the Invention

The present invention provides a defect management method and apparatus that manage a defect occurring in a disc in a manner suitable

for recording different types of data, thereby improving reproduction cha racteristics.

The present invention also provides a defect management method and apparatus that are applicable to a write once disc and manage a de fect occurring in that disc in a manner suitable for recording different type s of data, thereby improving reproduction characteristics.

According to an aspect of the present invention, there is provided a method of managing defects in a disc, comprising: (a) recording data in predetermined units of data; (b) verifying the recorded data to detect an area of the disc in which a defect exists; (c) designating from the area ha ving the defect to the following area containing data as a defective area o r designating only the area having the defect as a defective area; (d) rec ording information regarding the designated defective area as temporary defect information in a data area of the disc; and (e) recording informatio n, which is used to manage the temporary defect information, in a tempo rary defect management information area.

It is preferable that he method further includes (f) repeating (a) thr ough (e) before finalizing of the disc, wherein previously recorded inform ation is recorded with the temporary defect information during (d); and (g) recording information, which is most recently recorded in the temporary defect information area and the temporary defect management informati on area in a defect management area during the finalizing of the disc.

It is preferable that during (c), from the area having the defect to t he following area containing data is designated as a defective area, or on ly the area having the defect is designated as a defective area, dependin g on the type of the recorded data. Also, it is more preferable that durin g (c), only the area having the defect is designated as a defective area w hen the recorded data is AV data, and from the area having the defect to the following area containing data is designated as a defective area wh en the recorded data is control data.

According to another aspect of the present invention, there is provided a

method of managing defects in a disc, comprising: (a) recording data in p redetermined units of data; (b) verifying the recorded data to detect an ar ea of the disc in which a defect exists; (c) designating from the area havi ng the defect to the following area containing data as a defective area as a defective area, or designating only the area having the defect as a def ective area; (d) storing information regarding the designated defective ar ea as first temporary defect information in memory; (e) repeating (a) thro ugh (d) before a recording operation is expected to end; (f) reading the te mporary defect information from the memory and recording the temporar y defect information in a temporary defect information area of the data ar ea so as to correspond to the recording operation, when the recording op eration is expected to end; and (g) recording information, which is used t o manage the information recorded in the temporary defect information a rea in (f), in a temporary defect management information area.

It is preferable that during (f), information for designating the temp orary defect information area is further recorded in the temporary defect i nformation area.

It is preferable that the method further includes (h)

repeating (a) through (f) before finalizing of the disc, wherein previ ously recorded information is recorded with the temporary defect informa tion during (f) in the temporary defect information area; and (i) recording i nformation, which is most recently recorded in the temporary defect infor mation area and the temporary defect management information area, in a defect management area.

It is preferable that during (c), from the area having the defect to t he following area containing data is designated as a defective area, or on ly the area having the defect is designated as a defective area, dependin g on the type of the recorded data. It is more preferable that during (c), only the area having the defect is designated as a defective area when th e recorded data is AV data, and from the area having the defect to the fol lowing area containing data is designated as a defective area when the r

ecorded data is control data.

According to yet another aspect of the present invention, there is provided a recording apparatus comprising a recording/reading unit that r ecords data on or reads data from a disc; and a controller that verifies th e data recorded on the disc using the recording/reading unit so as to det ect an area of the disc in which a defect exists, designates from the area having the defect to the following area containing data as a defective are a or designates only the area having the defect as a defective area, creat es information regarding the designated defective area, provides the cre ated information to the recording/reading unit, controls the recording/read ing unit to record the created information as temporary defect information in a data area of the disc, creates management information for managin g the temporary defect information, provides the management informatio n to the recording/reading unit, and controls the recording/reading unit to record the management information in a temporary defect management area.

It is preferable that the controller controls the recording/reading un it to further record the previously recorded information with the informatio n, and controls the recording/reading unit to record information, which is most recently recorded in the temporary defect information area and the temporary defect management information area in a defect management area during finalizing of the disc. It is preferable that the controller desi gnates from the area having the defect to the following area containing d ata as a defective area, or designates only the area having the defect as a defective area, depending on the type of the recorded data. It is more preferable that the controller designates only the area having the defect as a defective area when the recorded data is AV data, and designates fr om the area having the defect to the following area containing data as a defective area when the recorded data is control data.

According to still another aspect of the present invention, there is provided a recording apparatus comprising memory; a recording/reading

unit that records data on a disc in predetermined units of data and reads the recorded data from the disc; and a controller that verifies the data rec orded on the disc using the recording/reading unit so as to defect an are a of the disc in which a defect exists; designates from the area having th e defect to the following area containing data as a defective area or desi gnates only the area having the defect as a defective area; stores inform ation regarding the designated defective area as first temporary defect in formation in the memory; repeats the verifying of the data, the designatin g of the defective area, and the storing of information regarding the desig nated defective area before a recording operation is expected to end; rea ds the temporary defect information from the memory when the recording operation is expected to end; provides the read temporary defect inform ation to the recording/reading unit; controls the recording/reading unit to r ecord the temporary defect information in a temporary defect information area of the data area in a manner corresponding to the recording operat ion; creates management information for managing the temporary defect information area; provides the management information to the recording /reading unit; and controls the recording/reading unit to record the manag ement information in a temporary defect management information area. It is preferable that the controller creates information for the temporary d efect information area, provides the created information to the recording/ reading unit, and controls the recording/reading unit to further record the created information in the temporary defect information area. It is prefer able that the controller controls the recording/reading unit to further recor d the previously recorded information with the information; reads informat ion, which is most recently recorded in the temporary defect information area and the temporary defect management information area, during the finalizing of the disc; and controls the recording/reading unit to record the most recently recorded information in the defect management area agai n. It is preferable that the controller designates from the area having th e defect to the following area containing data as a defective area or desi

gnates only the area having the defect as a defective area, depending on the type of the recorded data. It is more preferable that the controller designates only the area having the defect as a defective area when the recorded data is AV data, and designates from the area having the defect to the following area containing data as a defective area when the recorded data is control data.

Brief Description of the Drawings

The above and/or other aspects and/or advantages of the present invention will become more apparent and more readily appreciated by describing in detail embodiments thereof with reference to the accompanying drawings in which:

FIG. 1 is a block diagram of a recording apparatus according to a preferred embodiment of the present invention;

FIG. 2A illustrates a structure of a single record layer disc according to a preferred embodiment of the present invention;

FIG. 2B illustrates a structure of a double record layer disc according to a preferred embodiment of the present invention;

FIG. 3 illustrates details of the structures of the discs shown in FIGs. 2A and 2B;

FIG. 4 is a diagram illustrating a process in which temporary defect information is created and recorded, according to a preferred embodiment of the present invention;

FIG. 5 illustrates data structures of temporary defect information according to a preferred embodiment of the present invention;

FIG. 6 illustrates data structures of information regarding defect #i and information regarding temporary defect information #i, which are recorded in a temporary defect information area;

FIG. 7 is a flowchart illustrating a defect management method according to a preferred embodiment of the present invention; and

FIG. 8 is a flowchart illustrating a defect management method acc

ording to another preferred embodiment of the present invention.

Best mode for carrying out the Invention

FIG. 1 is a block diagram of a recording apparatus according to a preferred embodiment of the present invention. Referring to FIG. 1, the recording apparatus includes a recording/reading unit 1, a controller 2, a nd a memory 3. The recording/reading unit 1 records data on a disc 10 0, which is an information storage medium according to a preferred emb odiment of the present invention, and reads back the data from the disc 100 to verify the accuracy of the recorded data. The controller 2 perfor ms defect management according to the present invention. In this emb odiment, the controller 2 uses a verify-after-write method in which the ac curacy of data is verified after recording the data in predetermined units. More specifically, the controller 2 makes the recording/reading unit 1 to record user data on the disc 100 in predetermined units, and verifies the accuracy of the user data for detection of detects in the user data. Next , if a detect is detected, the controller 2 creates defect information that in dicates the position of a defective area on the disc 100. If an area cont aining a defect is detected, the controller 2 designates only the specific a rea as a defective area, or designates from the specific area to the follow ing area containing data. Every time defect information is created, the c ontroller 2 stores it in the memory 3. When the amount of stored defect information reaches a predetermined level, it is recorded as temporary defect information on the disc 100. Also, the controller 2 records mana gement information, which is used to manage the recorded temporary de fect information, as temporary defect management information on the dis c 100.

In this embodiment, recording temporary defect information and te mporary defect management information on the disc 100 is periodically p erformed per recording operation. A recording operation is a unit of wor k determined according to a user's intention or is a recording work to be

performed. According to this embodiment, a recording operation indicates a process in which the disc 100 is loaded into the recording apparatus, data is recorded on the disc 100, and the disc 100 is taken out from the recording apparatus. During the recording operation, data is recorded and verified at least once; in general, data is verified several times. When a user presses the eject button (not shown) of the recording apparatus in order to remove the disc 100 after recording of data, the controller 2 expects the recording operation to be terminated. Next, the controller 2 creates temporary defect information and temporary defect management information, and provides them to the recording/reading unit 1 to be recorded on the disc 100. The temporary defect information, which is obtained as a result of the recording and verifying by the controller 2, is stored in the memory 3.

If the recording of data on the disc 100 is completed, i.e., no more data will be recorded on the disc 100 (the disc 100 is to be finalized), the controller 2 records the temporary defect information and the temporary defect management information in a defect management area (DMA) of the disc 100.

FIGs. 2A and 2B illustrate structures of a disc according to a preferred embodiment of the present invention. FIG. 2A illustrates in detail a single record layer disc representation of disc 100 having a record layer *L0*. The disc 100 includes a lead-in area, a data area, and a lead-out area. The lead-in area is located in an inner part of the disc 100 and the lead-out area is located in an outer part of the disc 100. The data area is present between the lead-in area and the lead-out area, and divided into a user data area and a spare area. The user data area is an area where user data is recorded, and the spare area is the substitute area for a user data area having a defect, serving to compensate for loss in the recording area due to a defect. On the assumption that defects may occur within the disc 100, it is preferable that the spare area assumes 5% of the entire data capacity of the disc 100, so that a greater amount of data c

an be recorded on the disc 100. Also, it is preferable that the spare are a is provided at the end of the recording area of the disc 100. Especiall y, in the case of a write once disc, the spare area must be located at the end of the recording area of the disc. This allows slipping replacement t o be performed while the spare area data is recorded, starting from the in ner part toward the outer part of the disc 100.

In this embodiment, the spare area is present only between the us er data area and the lead-out area. If necessary, a portion of the user d ata area may be used as another spare area, that is, more than one spar e area may be present between the user data area and the lead-out area .

FIG. 2B illustrates a double record layer disc representation of dis c 100 having two record layers *L0* and *L1*. A lead-in area, a data area, and an outer area are sequentially formed from the inner part of the first r ecord layer *L0* to its outer part. Also, an outer area, a data area, and a l ead-out area are sequentially formed from the outer part of the second re cord layer *L1* to its inner part. Unlike the single record layer disc of FIG. 2A, the lead-out area is present in the inner part of the disc 100 of FIG. 2B. That is, the disc 100 of FIG. 2B has an opposite track path (OTP) i n which data is recorded starting from the lead-in area of the first record l ayer *L0* toward the outer area and continuing from the outer area of the s econd record layer *L1* to the lead-out area.

FIG. 3 illustrates details of the structures of the disc 100 shown in FIGs. 2A and 2B, according to embodiments of the present invention. R eferring to FIG. 3, a DMA is present at least once in the lead-in area, the lead-out area, or the outer area of the disc 100. Also, a temporary defe ct management area is formed at least once in the lead-in area or the lea d-out area. A temporary defect information area is formed in the data ar ea according to a recording operation.

In general, information which relates to managing defects in the di sc 100 is recorded in the DMA. Such information includes the structure

of the disc 100 for defect management, the position of defect information , whether defect management is performed or not, and the position and s ize of a spare area. In the case of a write once disc, new data is record ed after previously recorded data when the previously recorded data cha nges. In general, when a disc is loaded into a recording/reproducing app aratus, the apparatus reads data from a lead-in area and a lead-out area of the disc to determine how to manage the disc, and record data on or read data from the disc. However, if the amount of data recorded in the lead-in area increases, a longer time is spent on preparing the recordin g or reproducing of data after loading the disc. Accordingly, the present invention proposes temporary defect management information and tem porary defect information. That is, only the temporary defect managem ent information, which is comparatively more important than the temporar y defect information, is recorded in the lead-in area. The temporary def ect information is recorded in the data area. It is preferable that new inf ormation is added to the previously recorded information in the temporar y defect information area so that all recorded information is accumulated therein. The recording/reproducing apparatus reads the most recently r ecorded temporary defect information and detects defects throughout the disc based on the reading result. Thus, information regarding the locat ion of the most recently recorded temporary defect information is recorde d in the temporary defect management information area where the temp orary defect management information is recorded.

More specifically, information regarding a defect that occurred in a recording unit #1 and information regarding a defect that occurred in a r ecording unit #2 are recorded in a temporary defect information area #1 and a temporary defect information area #2, respectively. Defect mana gement information for managing the temporary defect information areas #1, #2, ..., and #n is recorded in the temporary defect management info rmation area. If additional data cannot be recorded on the disc 100 or a user does not wish to record any more data on the disc 100, i.e., the dis

c 100 needs to be finalized, the temporary defect information recorded in the temporary defect information area and the temporary defect management information recorded in the temporary defect management information area are all recorded in the DMA.

The reason for recording the temporary defect management information and the temporary defect information in the DMA again will now be explained. In the case that additional data will not be recorded on the disc 100, i.e., the disc 100 needs to be finalized, the temporary defect management information, which is updated several times, and the temporary defect information, which is recorded in the data area, are rewritten to the DMA of the lead-in area, thereby enabling the fast reading of information recorded on the disc 100. Also, it is possible to increase the reliability of information by recording the defect management information in a plurality of areas.

In this embodiment, defect information recorded in the temporary defect information areas #0 through #i-1 is recorded repeatedly in a temporary defect information area #i. Therefore, it is sufficient to read the defect information from the last temporary defect information area and record this information in the DMA again during the finalizing of the disc 100.

FIG. 4 is a diagram illustrating a process in which temporary defect information is created and recorded.

Here, a unit of data may be processed in units of sectors or clusters. A sector denotes a minimum unit of data that is managed in a file system of a computer or in an application, and a cluster denotes a minimum unit of data that can be physically recorded on a disc at once. In general, one or more sectors constitute a cluster.

There are two types of sectors: a physical sector and a logical sector. The physical sector is an area on a disc where a sector of data is to be recorded. An address for detecting the physical sector is called a physical sector number (PSN). The logical sector is a unit for managing data in a file system or in an application. An address for detecting the log

ical sector is called a logical sector number (LSN). A disc recording/reproducing apparatus detects the recording position of data using a PSN and, when recording data on a disc, the entire data is managed in units of LSNs in a computer or in an application. The relationship between an LSN and a PSN is changed by a controller of the recording/reproducing apparatus, based on whether or not the disc contains a defect and an initial position of recording data.

Referring to FIG. 4, *A* denotes a data area in which PSNs are allocated to a plurality of sectors (not shown) in ascending order. In general, each LSN corresponds to at least one PSN. However, since LSNs are allocated to non-defective sectors in ascending order, the correspondence between the PSNs and the LSNs is not maintained when a disc has a defective area, even if the size of a physical sector is the same as that of a logical sector.

① through ⑨ denotes units of data in which verifying work is performed after recording work. In detail, a recording apparatus records user data in section ①, returns to the start of section ①, and checks if the user data is appropriately recorded or a defect exists in section ①. If a defect is detected, only the area covering the defect in section ① is designated as a defective area. Here, the defect is designated as defect #1. Next, the recording apparatus records the user data in section ②, returns to the start of section ②, and checks if the user data is appropriately recorded or a defect exists in the start. If a defect is detected, only the area covering the defect in section ② is designated as a defective area and the defect is designated as defect #2. Likewise, defect #3 is determined with respect to section ③. However, in the case of section ③, from the area containing the defect to the following area containing data is designated as the defective area. Since a defect is not detected in section ④, a defective area is not determined in section ④.

Temporary defect information #1 is recorded when recording oper

ation #1 is expected to end, and after the recording and verifying of data i n the section ④, i.e., when a user presses the eject button of a recording apparatus or recording of user data allocated in a recording operation is completed. Temporary defect information #1 contains information reg arding defects #1 through #3 occurring in sections ① through ④. Only an area containing a defect is determined to be a defective area in secti on ④, and from the area containing a defect to the following area contai ning data is determined to be the defective area in sections ⑤ and ⑥.

Similarly, temporary defect information #2 is recorded according to reco rding operation #2. Temporary defect information #1 also contains infor mation regarding an area part in which user data is recorded according t o recording operation #1, the part having a defect and thus being design ated as a defective area. Also, temporary defect information #2 contain s information regarding an area part in which the user data is recorded a ccording to recording operation #2, the part having a defect and thus bei ng designated as another defective area. Also, temporary defect inform ation #2 further contains the information contained in temporary defect in formation #1.

When a defect is detected from an area of disc 100, data recordin g may be performed in one of two ways: (i) only the specified area is desi gnated as a defective area, data recorded in the defective area is not rew ritten, and data recording is continued after the defective area; and (ii) fro m the area containing the defect to the following area containing data is designated a defective area, data recorded in the defective area is rewritt en, that is, the defective data is restored using slipping replacement, and then, the data recording is continued. Selection of the above ways (i) a nd (ii) is determined depending on the type of data to be recorded. For i nstance, if the data to be recorded is AV data that needs to be reproduce d in real time, (i) is selected, that is, only the area containing the defect is designated as a defective area and data recorded in the defective area i s not rewritten. In contrast, if the data to be recorded is control data, su

ch as navigation data that is used to reproduce, search for, or edit the AV data, (ii) is selected. In data reproduction, the degree of error due to control data loss is greater than that due to AV data loss.

The reason for choosing to rewrite data recorded in a defective area, based on data characteristics will now be described. In general, AV data needs to be reproduced in real time because it is perceived by human ears when it is reproduced. Human visual and auditory senses are more sensitive to an error in real-time reproduction of AV data than an error in reproduction of specific AV data content caused by a trivial defect contained in the AV data. In fact, human ears are incapable of detecting an error when audio data is incompletely reproduced. As specified previously, when an area of a disc is designated as a defective area, slipping replacement can be used to rewrite data to a following area. That is, when an area of a disc is designated as a defective area, the following area where data is recorded is also considered as unavailable and determined to be a defective area, and the data recorded in the defective area is rewritten. In this case, the defective area is skipped and data is read from the next area during reproduction of the data. However, skipping the defective area causes a delay in reading data from the disc, and the delay in reading makes it difficult to reproduce data in real-time. As described above, human ears are more sensitive to an error caused by a failure of real-time reproduction than an error caused by incomplete reproduction of AV data. In general, a disc drive included in a reproducing apparatus has various types of error correction functions such as error correction code (ECC), and is thus capable of restoring at least a portion of data that cannot be appropriately read during the reproduction operation. For this reason, when a defect exists in an area of a disc during AV data recording, only the specified area is designated as the defective area and data recorded in the defective area is not rewritten in another area.

A case exists where AV data is reproduced in real time but it need not to be recorded in real time. The case includes storing AV data in a

n auxiliary storage device, such as a hard disc drive (HDD), and recordin g the stored AV data on the disc 100. That is, AV data can be recorded using an editing tool for AV data. In particular, AV data that does not n eed to be recorded in real time can be easily recorded according to the p resent invention.

In contrast, if only a portion of control data is lost, it is difficult to re produce, edit, and search for the control data. Thus, if a defect exists in an area of a disc during the recording of control data, both the area havi ng the defect and the following area containing data is designated as a d efective area and data recorded in the defective area is rewritten in anoth er area.

The diagram of FIG. 4 illustrates data recording, more specifically, a first recording operation on a disc where a defect exists, using one of t wo ways: (i) only the area having the defect is designated as a defective area and data recording is continued after the defective area without rew riting data previously recorded in the defective area, and (ii) a defective a rea is designated to include the area having the defect and the following area containing data and the data previously recorded in the defective ar ea is rewritten. However, the present invention is not limited to this des cription, that is, disc defects may be processed another way rather than t he way (i) or the way (ii), depending on a format of recorded data.

FIG. 5 illustrates data structures of temporary defect information a ccording to preferred embodiment of the present invention. Referring to FIG. 5, temporary defect information #1 contains information regarding defect #1, defect #2, and defect #3. The information regarding defect # 1 discloses the position of defect #1 recorded in the disc, the information regarding defect #2 discloses the position of defect #2, and the informati on regarding defect #3 discloses the position of defect #3.

Temporary defect information #1 also includes the information reg arding defect #1, the information regarding defect #1, the information reg arding defect #3, and the information regarding temporary defect informa

tion #1. The information regarding temporary defect information #1 indicates the position of temporary defect information #1. It is not required to read the information recorded in temporary defect information #1 during reproduction of user data, since the user data is not recorded in temporary defect information #1. That is, for the reproduction of the user data, it is meaningless to distinguish between defective area #i and temporary defect information #1. Therefore, temporary defect information #1 contains the information regarding its position and thus can be used as useful information, for example, it can be used to indicate that the user data is not recorded in temporary defect information #1 during the reproduction of the user data.

Temporary defect information #2 further contains information regarding defects #4, #5, and #6, in addition to the information recorded in temporary defect information #1. Temporary defect information #2 also contains information regarding the position of temporary defect information #1.

FIG. 6 illustrates data structures of information regarding defect #i recorded in a temporary defect information area, and information regarding temporary defect information #i. Referring to FIG. 6, the information regarding defect #i includes first state information, second state information, starting and ending points, and a reserved area of defect #i. State information is flag information that indicates whether the present area is a defective area in which a defect exists or is a temporary defect information area in which temporary defect information is recorded. In this embodiment, the first state information is included in the information regarding defect #i and thus must be understood as flag information indicating that the present area is a defective area. The second state information is flag information that indicates one of two options. The first option declares that only the area having the defect is designated as the defective area and that data recording is continued after the defective area without any rewriting of the data previously recorded in the defective area. The seco

nd option declares that from the area having the defect to the following a rea containing data is designated as a defective area and the data record ed in the defective area is rewritten. In the case of defect area #1 show n in FIG. 4, which includes only the area having the defect, the second st ate information discloses designation of a defective area covering defect area #1 and data recorded in defect area #1 as not rewritten. The infor mation regarding the starting point represents the start of the present are a, i.e., the start of the defect #i. The information regarding the ending p oint represents the end of the present area, i.e., the end of the defect #i. The reserved area is referred to as an area that is reserved for recordi ng other information.

The information regarding temporary defect information #i also incl udes first state information, second state information, starting and ending points, and a reserved area of temporary defect information #i. State i nformation is flag information that indicates whether the present area is a defective area in which a defect exists or is an area in which temporary defect information is recorded. The first state information included in th e information regarding temporary defect information #i is flag informatio n indicating that a present area is an area in which temporary defect infor mation is recorded, rather than an area in which a defect exists. The in clusion of the second state information into the information regarding tem porary defect information #i is optional. The second state information is flag information indicating the same as described for the information reg arding defect #i. If the verify-after-write method is also performed on data recorded in a temporary defect information area and the data is rewritte n when a defect exists in the temporary defect information area, the seco nd state information is flag information indicating the rewriting of the data

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Hereinafter, a defect management method according to the prese nt invention will be described.

FIG. 7 is a flowchart illustrating a defect management method acc

ording to a preferred embodiment of the present invention. Referring to FIG. 7, in action 701, a recording apparatus records defect information, r egarding data recorded according to a first recording operation, as first te mporary defect information in a data area of a disc. This process serve s to manage the defect in the disc. In action 702, the recording apparat us records defect management information, which is used to manage the first temporary defect information, as first temporary defect managemen t information in a temporary defect management information area in at le ast one of a lead-in area and a lead-out area of the disc. In action 703, the recording apparatus records the first temporary defect information an d defect information, regarding data recorded according to a second reco rding operation, as second temporary defect information in the data area.

In action 704, the recording apparatus records defect management inf ormation, which is used to manage the second temporary defect informat ion, as second temporary defect management information in the tempora ry defect management information area. In action 705, it is checked whet her the disc needs to be finalized or not. In action 706, if it is determine d in step 705 that the disc does not need to be finalized, actions 701 thro ugh 704 are repeated while indexes, which are given to the recording op erations, the temporary defect information, and the temporary defect ma nagement information, are increased by 1. During the finalizing of the di sc, the most recent defect management information and temporary defec t information, which are recorded until step 704, are recorded in a DMA i n action 707. That is, the most recently recorded temporary defect man agement information and temporary defect information are recorded as t he final temporary defect management information and temporary defect information in the DMA. In action 707, the final temporary defect infor mation and defect management information may be recorded repeatedly in the DMA to increase the reliability of data detection. Further, the verif y-after-write method may be performed on the final temporary defect ma nagement information and temporary defect information. If a defect is d

etected from this information, the area of the disc in which the defect exis ts and data recorded after the area with the defect may be regarded as u navailable, i.e., they are designated as a defective area, and the final te mporary defect management information and temporary defect informati on may be recorded again after the defective area.

FIG. 8 is a flowchart illustrating a defect management method acc ording to another embodiment of the present invention. Referring to FI G. 8, a recording apparatus records user data on a data area of a disc in predetermined units of data to facilitate the verify-after-write method, in a ction 801. In action 802, the data recorded in action 801 is verified to d etect the existence of detects in any area of the data area where a defect exists. In action 803, it is determined whether data recorded in the are a having the defect will be rewritten or not. As mentioned above, the re writing of data is determined in consideration of the characteristics of dat a to be recorded. In one option, only the area with a defect is designate d as the defective area and data recorded in the defective area is not rew ritten. In the other option, both the area with the defect and the followin g area containing data are designated as the defective area and data rec orded in the defective area is rewritten.

If it is determined in action 803 that the data recorded in the area having the defect will not be rewritten, defect information is created in act ion 804 and used to designate only the area having the defect as the def ective area. In contrast, if it is determined in action 803 that the data re corded in the area having the defect will be rewritten, defect information i s created in action 805, and used to designate the area from the area ha ving the defect to the following area containing data as the defective area . In action 806, the defect information created in action 804 or action 80 5 is stored as first temporary defect information. In action 807, it is chec ked whether a recoding operation is expected to end. If it is determined in step 807 that the recording operation is not likely to end, actions 801 t hrough 806 are repeated before the end of the recording operation.

If it is determined in action 807 that the recording operation is likel y to end, i.e., the recording of the user data is complete by user input or according to the recording operation, the first temporary defect informatio n is read and recorded in temporary defect information area #1 of the dat a area, in action 808. In action 809, information designating temporary defect information area #1 as a defective area is further recorded in first t emporary defect information area #1. In action 810, first temporary defe ct management information #1, which is used to manage temporary defe ct information #1, is recorded in a temporary defect management informa tion area. In action 811, it is checked whether the disc needs to be finali zed. If it is determined in action 811 that the disc is not to be finalized, actions 801 through 810 are repeated before the finalizing. In action 81 2, indexes, which are given to the temporary defect information, the temp orary defect information area, and the temporary defect management inf ormation, are increased by 1 whenever actions 801 through 810 are repe ated. If it is determined in action 811 that the disc needs to be finalized, the most recently recorded temporary defect information #i and tempora ry defect management information #i are recorded as the final temporary defect information and temporary defect management information in a DMA in action 813. The final defect information and defect managemen t information may be recorded repeatedly in the DMA several times, ther eby increasing the reliability of data detection. Further, the verify-after-write method may be performed on the final temporary defect managem ent information and temporary defect information. If a defect is detecte d from this information, the area of the disc in which the defect exists and the following area containing data may be regarded as unavailable, i.e., the two areas are designated as a defective area, and the final temporar y defect management information and temporary defect information may be again recorded after the defective area.

Industrial Applicability

As described above, the present invention provides a disc defect management method that is applicable to write once discs and suitable f or recording different types of data, thus enabling more appropriate real-t ime data reproduction. Further, according to the present invention, a te mporary defect information area is allotted to the data area of a disc, whi ch stores defect information without reducing the recording capacity of th e disc. During the finalization of a disc, only the most recently recorded defect information is read from the temporary defect information area an d recorded in a defect management area (DMA), thereby enabling efficie nt use of the DMA whose recording capacity is limited. Meanwhile, it is possible to record user data on even a write once disc while performing d efect management, thereby more stable backup operations can be perfor med without interruptions.

Although a few embodiments of the present invention have been s hown and described, it would be appreciated by those skilled in the art th at changes may be made in this embodiment without departing from the principles and spirit of the invention, the scope of which is defined in the claims and their equivalents.